

NEW FOSSILS OF *SIVATHERIUM GIGANTEUM* (GIRAFFIDAE, MAMMALIA) FROM THE UPPER SIWALIKS OF THE INDIAN SUBCONTINENT

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Abstract Fossil material of *Sivatherium giganteum* is reported here from the Upper Siwaliks of the Indian Subcontinent. The paper restricts itself only to the systematic description of this fossil material. The material consists of a half right maxillary second molar and a left mandibular fragment with partial M₂ and M₃ of *Sivatherium giganteum* collected from the Tatrot Formation of the Upper Siwaliks exposed north of Gobindpur village near Naraingarh Town (Haryana), northwest India. These specimens were found associated with several Pliocene mammalian taxa, which include *Stegodon insignis*, *Hexaprotodon sivalensis*, *Leptobos falconeri*, and yet to be identified Bovini. The mammalian faunal assemblage suggests an Early Pliocene age for the Tatrot deposits of Upper Siwaliks in the area. The present discovery is significant in the sense that records of *Sivatherium giganteum* are very rare in the Indian Subcontinent. Moreover, it is for the first time that *Sivatherium giganteum* is being described from the Upper Siwaliks of the study area.

Keywords: *Sivatherium*, Giraffidae, Tatrot Formation, Upper Siwaliks

INTRODUCTION

The family Giraffidae in recent times is represented by two genera, *Okapia* Lankester (1902) and *Giraffa* Linnaeus (1758), both of which are confined to Africa. Giraffidae were more widespread and taxonomically more diverse during the Neogene of the Old World (Bohlin, 1926; Hamilton, 1978; Heintz et al. 1981; Geraads, 1985, 1986; Janis and Scott, 1987; Gentry, 1993; Gentry et al. 1999; Geraads et al. 2004; Rios et al. 2017). The Siwalik giraffids are represented by three subfamilies - i.e., Palaeotraginae, Sivatheriinae, and Giraffinae (Colbert, 1935). The so-called subfamily Palaeotraginae comprises only the genus *Giraffokeryx*, whereas subfamily Sivatheriinae includes the genera *Sivatherium*, *Bramatherium*, *Helladotherium*, and *Hydasphitherium*.

The subfamily Giraffinae includes the genus *Giraffa*. The three subfamilies of Siwalik giraffids evolved concurrently but their migration to Siwaliks occurred at different times. In the Siwaliks, the presence of Palaeotraginae and Giraffinae was established earlier than that of Sivatheriinae (Akhtar et al. 1991; Solounias, 2007).

Sivatherium giganteum is a gigantic giraffid restricted to Upper Siwaliks of India and Pakistan (Falconer & Cautley, 1835; Bohlin, 1926; Colbert, 1935), found near the Pliocene-Pleistocene boundary of the Himalayan foothills (Patnaik & Nanda, 2010). The first report of *Sivatherium giganteum* was by Falconer & Cautley (1835) from the Indian Siwaliks. Since then a number of genera and species of fossil giraffids has been recorded from various formations of the Siwaliks by different workers such as Lydekker (1876, 1878), Pilgrim (1910, 1911), Matthew (1929), Gaur (1987), Nanda & Shukla (2001), Khan & Sarwar (2002) & Khan et al. (2011). Fossil remains of *Sivatherium giganteum* are very rare in

comparison to other fossil giraffids known from the Indian Siwaliks. The fossil taxon *Sivatherium* itself is represented here by only one species, *Sivatherium giganteum*, which is known from the Pinjor Formation of Upper Siwaliks (Gaur, 1987). Meanwhile, the genus *Sivatherium* is known by two species, namely *S. hendeyi* and *S. maurusium*, from Africa (Harris et al. 2010).

The Upper Siwaliks exposed near Naraingarh Town of Haryana State in northwest India yielded a rich collection of fossil mammals but the occurrences of *Sivatherium giganteum* appear to be very rare here (Kumar, 2009, 2014). Indeed, there is no published report of the genus *Sivatherium* from the Upper Siwaliks exposed near Naraingarh area until now. The specimens reported here – PUA/SK- 07/49, a half right maxillary second molar, and PUA/SK/ -06/ 34, a left mandibular fragment with partial M₂ and M₃ – were collected *in situ* from a greyish yellow mudstone layer of the Tatrot Formation of the Upper Siwaliks exposed north of Gobindpur Village. (Figs. 1, 2).

This report is significant in the sense that it represents the first record of *Sivatherium giganteum* from the present study area, and a new addition to our knowledge of this extinct taxon.

According to the Dennell et al. (2006), the Upper Siwaliks of the Indian Subcontinent span the Late Pliocene to Middle Pleistocene time interval (3.3– 0.6 Ma).

No radiometric dates are as yet available for the Tatrot Formation of India. Most of the magnetostratigraphic studies were conducted in the Pakistan Siwaliks whereas in India, only scanty magnetostratigraphic data are available (Nanda, 2013).

In the Indian Siwaliks the first magnetostratigraphic investigations of the Upper Siwaliks near Suketi and in the

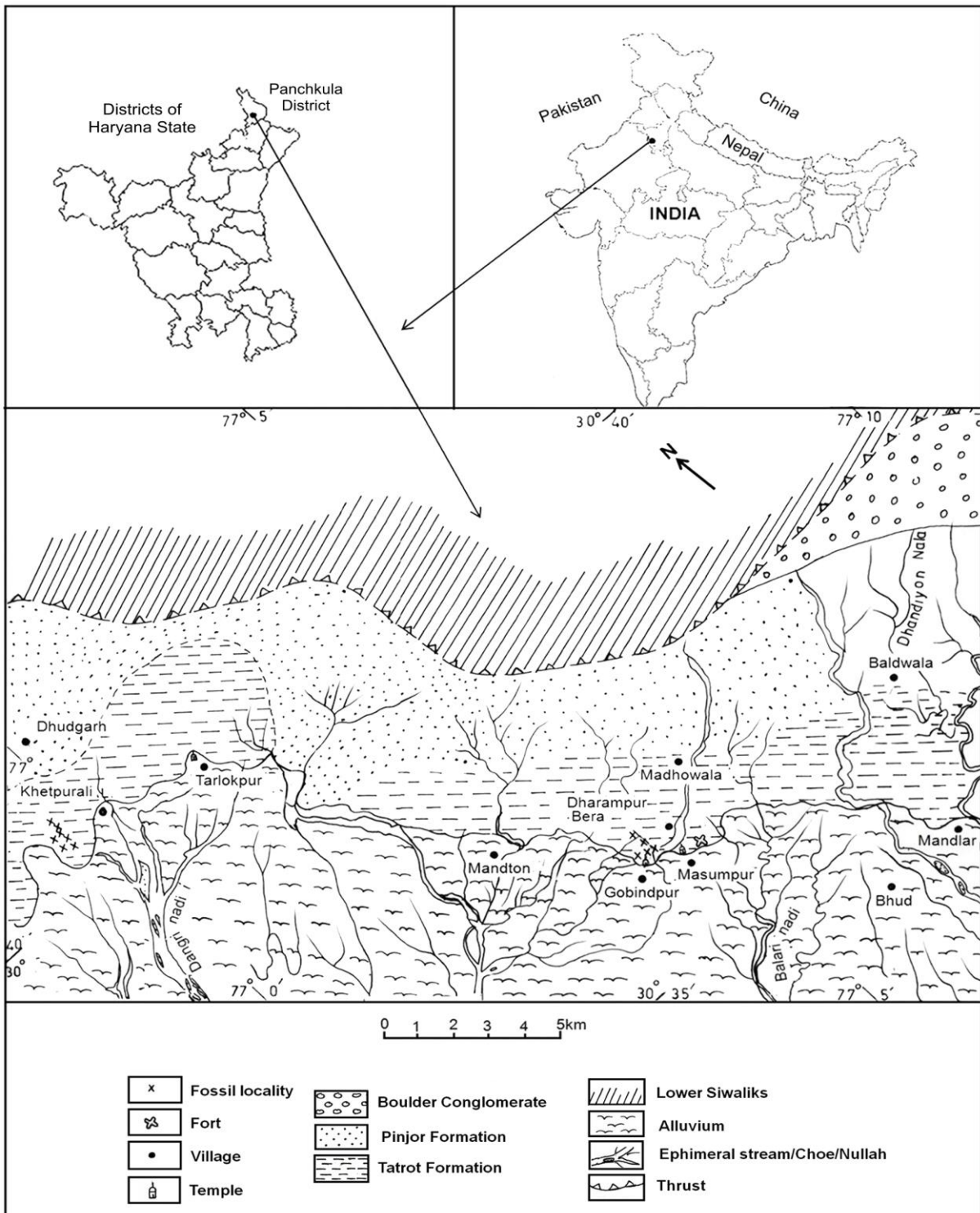


Fig. 1 Generalized locality map of the study area.

Chandigarh region were conducted by Azzaroli & Napoleone (1982) and Tandon et al. (1984), and these placed the Tatrot/Pinjor formational boundary at the Gauss/Matuyama transition at about 2.5 Ma. Azzaroli & Napoleone (1982) placed the lower limit of the Tatrot Formation in the Suketi area at 3.15 Ma. However, studies in the Pakistan Siwaliks by Johnson et al. (1982) placed the Dhok Pathan/Tatrot formational boundary at 5.1 Ma. A radiometric age of 2.53 Ma was assigned by

Johnson et al. (1982) to the volcanic tuff layer in the Kotal Kund and Jalalpur Upper Siwalik sections of Pakistan, which helped to identify the boundary between the Gauss and Matuyama magnetic chrons that is considered to mark the transition between the Tatrot and Pinjor formations (Opdyke et al. 1979; Johnson et al. 1982; Barry et al. 1982; Hussain et al. 1992 & Nanda, 2002). The present fossil specimens were found associated with several Pliocene mammalian taxa, which include *Stegodon*

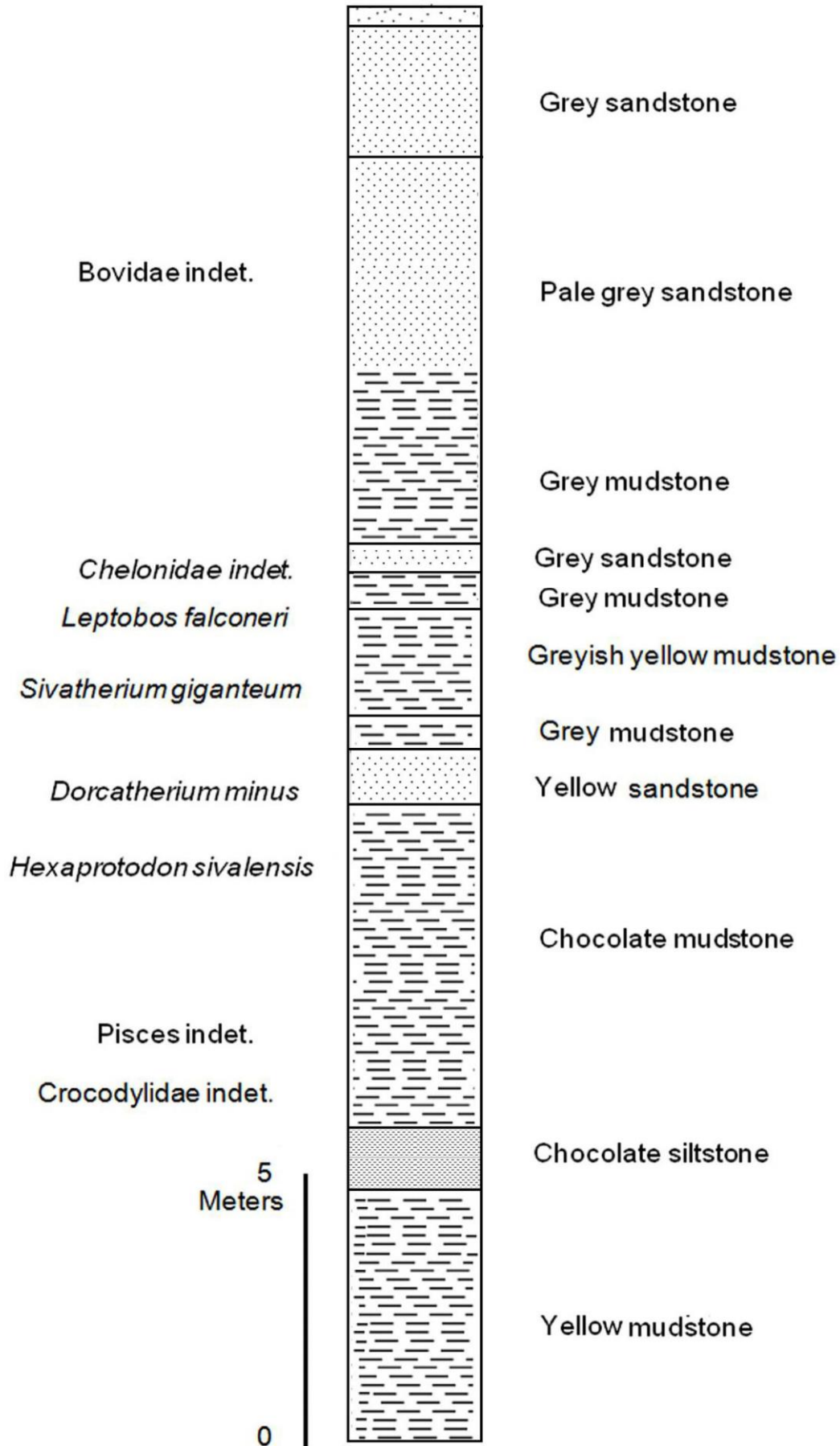


Fig. 2 Local stratigraphic section of the Tatrot Formation in the study area.

insignis, *Hexaprotodon sivalensis*, *Leptobos falconeri*, and yet to be identified Bovini (Fig. 2). According to Gaur (1987), the mammalian faunal assemblage of the Tatrot Formation of the Upper Siwaliks in the study area is suggestive of an Early Pliocene age. Future discoveries of *Sivatherium giganteum* from the present study area and magnetostratigraphic data may throw better light on the precise old age of this genus in the Indian Siwaliks.

Abbreviations: AMNH – American Museum of Natural History, New York; NHMUK – Natural History Museum, London; PUA – Panjab University Anthropology; UGC – University Grant Commission; L – length; B – breadth; I – index; M – molar, P – premolar; Ma – Million years ago.

Systematic Palaeontology

Order	Artiodactyla	Owen, 1848
Suborder	Ruminantia	Scopoli, 1777
Superfamily	Giraffoidea	Gray, 1821
Family	Giraffidae	Gray, 1821
Subfamily	Sivatheriinae	Bonaparte, 1850
Genus	<i>Sivatherium</i>	Falconer and Cautley, 1835
Species	<i>Sivatherium giganteum</i>	Falconer and Cautley, 1835

Holotype: NHMUK-15283, a skull.

Type Horizon: Upper Siwaliks.

Additional Material: PUA/SK - 07/49, a half right maxillary second molar;

PUA/SK- 06/ 34, a left mandibular fragment with partial M₂ and M₃.

Horizon: Tatrot Formation of the Upper Siwaliks.

Locality: About 1km north of Gobindpur Village.

Description

PUA/SK-07/49

The present specimen is a half right maxillary second molar. The tooth preserves its complete mesial half and only a small part of the distal half of the molar. The occlusal aspect of the preserved part of the molar shows two major cusps in the anterior half, namely, mesio-buccally, the metacone, and mesio-lingually, the protocone. The metacone is broad in the middle with a strongly developed median rib and sloping anterior and posterior ridges. The anterior ridge is united with the parastyle whereas the posterior ridge is connected with the anterior ridge of the metacone, which is completely broken. The lingual part of the specimen displays a roughly crescent-shaped protocone the mesial limb of which extends up to the mesio-lingual aspect of the metacone.

The metacone and protocone are separated by a deep and broad pre-fossette, in the mesial half of the molar. Only a small part of the mesial portion of the hypocone is preserved. The molar displays a median basal pillar on its lingual side which extends up to one third the height of the crown. A moderately developed cingulum can be seen around the base of the lingual side of the protocone, ex-

tending from the basal pillar to the middle of the mesial side. A strong facet is visible on the mesial side of the molar. The enamel is thick and rugose. The tooth shows slight wear. The colour of enamel is dark brownish yellow and that of dentine is dull brown.

PUA/SK- 06/34

The specimen under description is a left mandibular fragment with partially preserved M₂ and M₃. The preserved portion of the mandibular ramus is deep. It is eroded on the lingual face, exposing portion of the roots of the third molar, while distal to the third molar is laterally compressed.

M₂

The molar is half broken and badly preserved. The crown details cannot be clearly demarcated as all the major cuspids as well as stylids are missing. The tooth shows heavy wear.

M₃

This molar is highly worn and is roughly rectangular in outline. The crown displays only two cuspids, the mesio-lingual metaconid and the mesio-buccal protoconid. In the mesial half, the paraconid and the protoconid are separated by a crescent-shaped pre-fossettid. The distal aspect of the tooth is badly damaged therefore the major cuspids in this area, namely, the metaconid, hypoconid, and entoconid as well as the stylids such as the parastylid, mesostylid, and metastylid, are completely missing.

Only a trace of the mesial part the post-fossettid is preserved. The hypoconulid is also broken. Only a trace of cingulum can be seen at the mesio-buccal border of the protoconid. On the lingual side the roots of M₃ are visible; these extend up to the lower one-third of the ramus. The colour of enamel is yellow-greyish brownish while the dentine is medium brown in colour.

DISCUSSION AND COMPARISONS

Several genera of fossil giraffids, namely, *Giraffa*, *Giraffokeryx*, *Sivatherium*, *Hydaspitherium*, *Helladotherium*, and *Bramatherium*, are known from the Siwaliks of India and Pakistan. Several workers in the past, such as Lydekker (1876, 1878), Pilgrim (1910, 1911), Matthew (1929), Gaur (1987), Nanda & Shukla (2001), Akhtar et al. (1991), Khan & Sarwar (2002), and Khan et al. (2011), respectively, have reported fossil Siwaliks giraffids. Although the Upper Siwaliks of the study area have yielded many mammalian fossils, those of *Sivatherium giganteum* are very rare when compared to other mammals of the fauna (Kumar, 2009). So far, *Sivatherium giganteum* is the only known species of the genus *Sivatherium* from the Upper Siwaliks of the Indian Subcontinent (Gaur, 1987). The earliest occurrence of the genus *Sivatherium* was reported by Falconer & Cautley (1835; see also Bohlin, 1926; Colbert, 1935; Gaur, 1987). The present

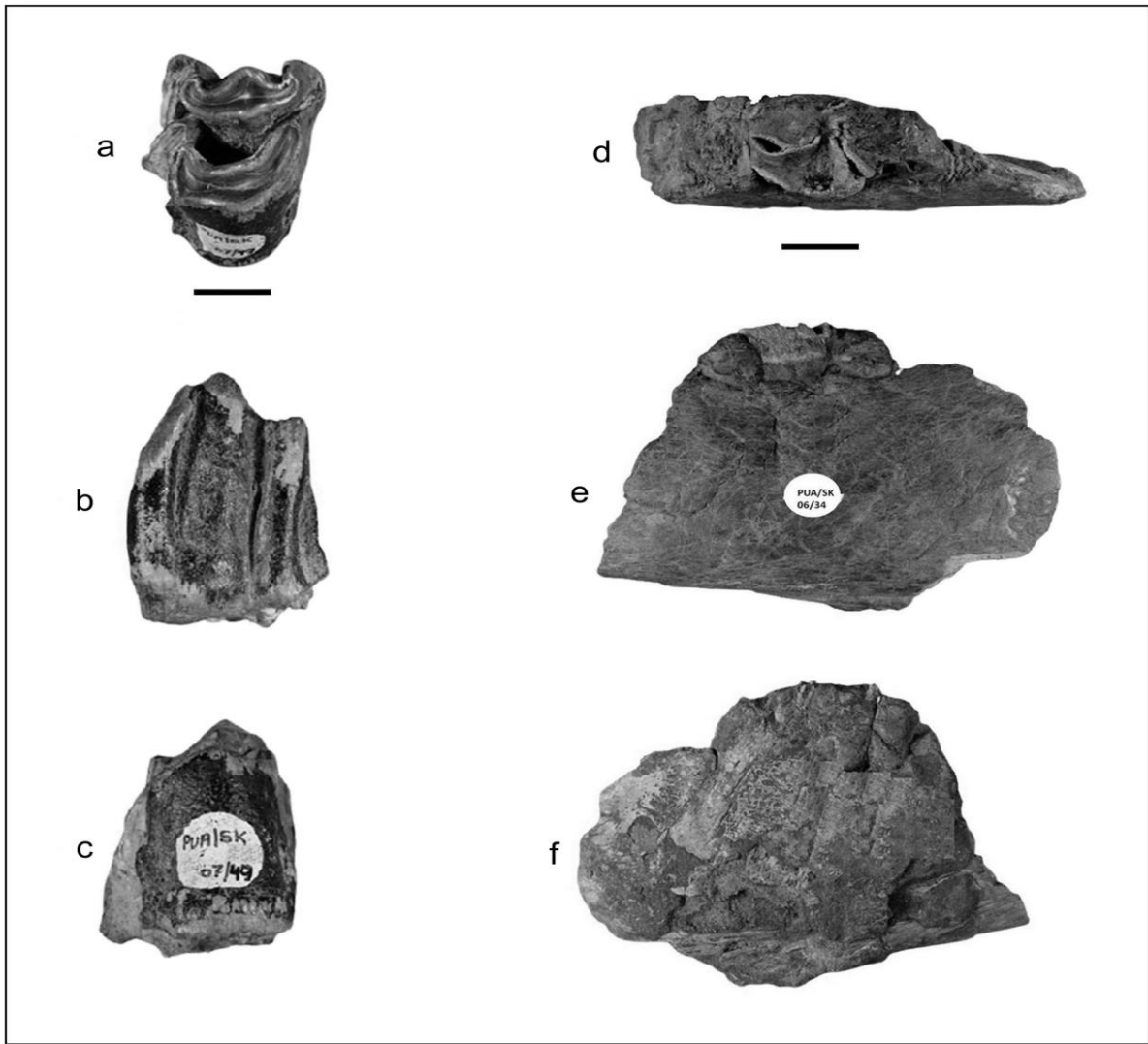


Fig. 3 (a, b, c), PUA/SK - 07/49, **a** half right maxillary M_2 of *Sivatherium giganteum* in **a**) occlusal view; **b**) buccal view; **c**) lingual view. (**d**, **e**, **f**), PUA/SK- 06/ 34, a left mandibular fragment with partial M_2 and M_3 of *Sivatherium giganteum* in **d**) occlusal view; **e**) buccal view; **f**) lingual view. Bar scale represents 2cm.

discovery is significant in the sense that it represents the first report of *Sivatherium giganteum* from the Tatrot Formation of the Upper Siwaliks of Indian Subcontinent. As yet, there is no published report of the *Sivatherium giganteum* from the Tatrot Formation of the Upper Siwaliks of the Indian Subcontinent. The problem of the boundary between the Pliocene and the Pleistocene is still very doubtful both from geological and faunal viewpoints. Accordingly, due to the paucity of relevant fossil material and to limited magnetostratigraphic studies in the present study area, it is not possible to comment about the precise age of the genus *Sivatherium* in the Siwaliks. Hence, it is necessary to extensively explore the Siwaliks in order to solve this problem.

The Siwalik giraffids can be grouped according to their size into larger-bodied and smaller-bodied forms, respectively (Colbert, 1935; Solounias, 2007; Harris et al. 2010). The group of large forms includes *Sivatherium giganteum*, *Bramatherium megacephalum*, and *Hydaspthierium megacephalum*. whereas smaller forms include *Giraffa punjabiensis* and *Giraffokeryx punjabien-*

sis. According to (Colbert, 1935, see also Geraads and Gülec, 1999), Siwalik giraffids can be distinguished on the basis of their dentition, separating the genera *Sivatherium*, *Bramatherium*, and *Hydaspthierium* with large- sized teeth in comparison with the genera *Giraffa* and *Giraffokeryx* with small teeth.

The studied specimens (PUA/SK-07/49 and PUA/SK-06/34) show large- sized teeth with moderate height, and with a thick and rugose enamel, both of which are typical characteristic features of the genus *Sivatherium* (Table 1). According to Falconer & Cautley (1836), in the genus *Sivatherium* the protocone is truly crescentic with its praeprotocrista projected backward. The specimen PUA/SK-07/49 can be differentiated from the genus *Bramatherium* which has an L-shaped protocone; whereas in *Sivatherium* the protocone is crescent-shaped. According to Gentry (1997), the size of teeth is the only criterion to differentiate the Siwalik giraffid species in addition to the presence of styles/stylids, obliteration in the central fossettes, and the rugosity.

Table.1
Comparative measurements (mm) of the molars (Upper/Lower) of *Sivatherium giganteum* with other known giraffid genera from Siwaliks

Measurements (in mm)	Present Specimens		<i>Sivatherium giganteum</i> Gaur, 1987	<i>Sivatherium giganteum</i> Colbert, 1935			<i>Giraffa punjabiensis</i> Colbert, 1935	<i>Giraffokeryx punjabiensis</i> Colbert, 1935		<i>Bramatherium megacephalum</i> Lydekker, 1878	<i>Hydaspiatherium megacephalum</i> Nanda & Shukla, 2001
	PUA/SK-07/49	PUA/SK-06/34		AMNH 19883	AMNH 19797	AMNH 2086		AMNH 19472	AMNH 19587		
M ² Max. mesio-distal diameter (L)	47.00*	--	49.00	56.00	--	--	27.00	--	--	--	--
M ² Max. bucco-lingual diameter (B)	50.20	--	50.00	56.00	--	--	25	--	--	--	--
M ² Index (B/L X 100)	107.00	--	102.04	100.00	--	--	92.50	--	--	--	--
M ₂ Max. mesio-distal diameter (L)	--	--	--	--	54.00	--	--	34.71	38.00	--	42
M ₂ Max. bucco-lingual diameter (B)	--	36.69	--	--	39.00	--	--	18.09	28.00	--	28
M ₂ Index (B/L X 100)	--	-	--	--	72.22	--	--	52.11	73.68	--	67
M ₃ Max. mesio-distal diameter (L)	--	62.54*	--	--	--	68.00	--	--	50.00	--	44+
M ₃ Max. bucco-lingual diameter (B)	--	34.05	--	--	--	33.00	--	--	28.50	--	33
M ₃ Index (B/L X 100)	--	54.44	--	--	--	48.52	--	--	57.00	--	--

*Estimated

The present specimens differ from *Giraffa punjabiensis* and *Giraffokeryx punjabiensis* in their overall size (Table 1). These can be also differentiated from *Hydaspitherium megacephalus* which is smaller than *Sivatherium giganteum*. The above comparisons of the specimens suggest show close morphological and dimensional similarities with *Sivatherium giganteum*. Moreover, *S. giganteum* is the only species of the genus *Sivatherium* known from the Upper Siwaliks of India (Gaur, 1987) Hence these specimens are assigned to *Sivatherium giganteum*.

CONCLUSIONS

The selenodont tooth pattern seen in the studied specimens indicates that the teeth belong to a ruminant. The large size and low crowns indicate that they belong to the Giraffidae, rather than to any other ruminant group. The thick and rugose enamel is indicative of *Sivatherium giganteum*. No worker has yet reported the occurrence of any other species of the genus *Sivatherium* except for *S. giganteum* from the Upper Siwaliks of India. Earlier, *Sivatherium giganteum* was recovered from the Pinjor Formation of Upper Siwaliks (Gaur, 1987). The present report extends the range of the genus *Sivatherium* to the Tatrot Formation, whereas it was hitherto known only from the Pinjor Formation of the Upper Siwaliks of the Indian Subcontinent.

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